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(56) Documents cited
GB A 2088047
GB A 2045425
GB 1595423
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GB 1411285
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GB 0972394
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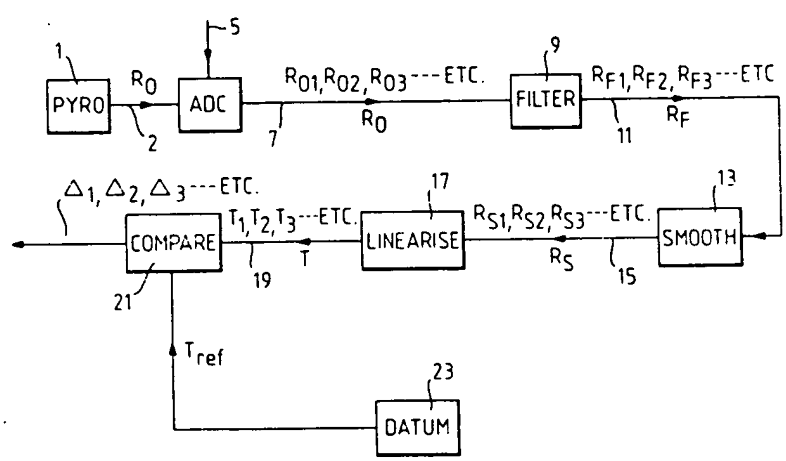
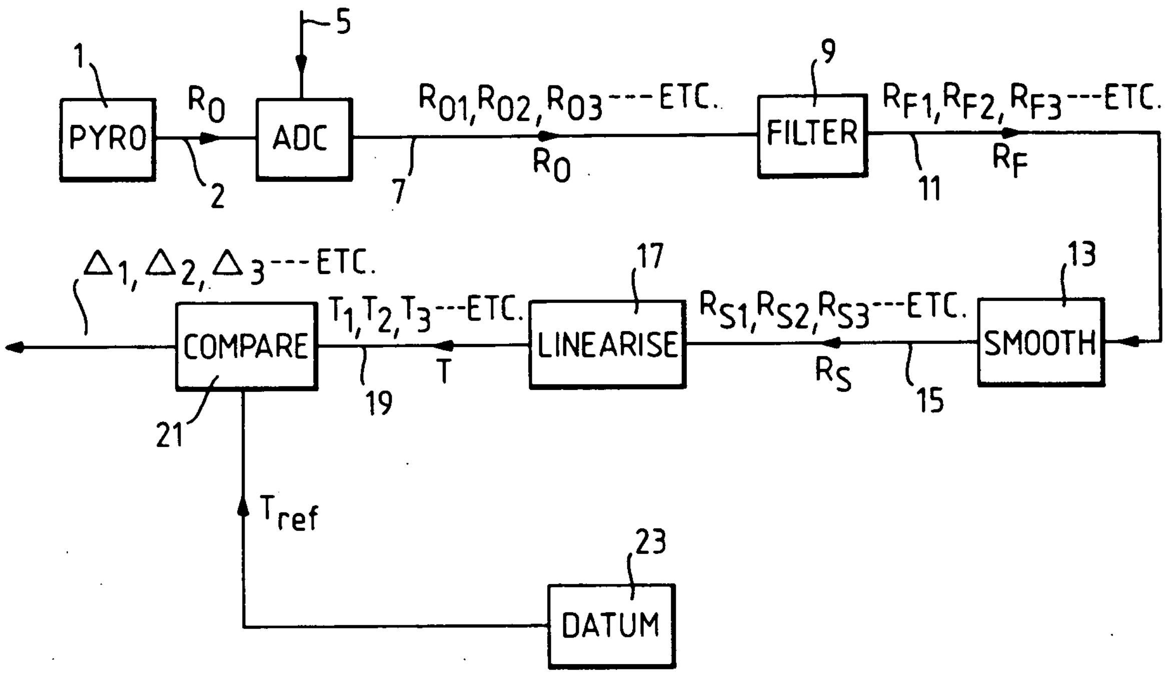
(54) **Generation of a signal dependent upon temperature of gas turbine rotor blades**

(57) Apparatus for the generation of a monitor signal for use in the operation of a gas turbine engine, the monitor signal being dependent upon the temperatures of a stage of turbine rotor blades in the gas turbine engine, includes an optical radiation pyrometer (1) having an output signal (R_o) which, ignoring radiant interference, is representative of the real-time average radiance of the hottest parts of an integer number of the turbine rotor blades, the integer number being a fraction of the total number of blades on the rotor. After analogue-to-digital-conversion in an ADC (3), subsequent processing is carried out by means of a filter function (9) for removal of radiant interference, a smoothing function (13) for reduction of fluctuations in radiance signal strength caused by variations in average radiance of neighbouring blades, a linearising function (17) for conversion to a temperature signal (T), and a comparison function (21) for production of a control signal (Δ) by comparing the temperature signal (T) with a reference temperature signal (T_{ref}) produced by a datum unit (23).



GB 2 133 877 A


PYRO
ADC
FILTER
SMOOTH
LINEARISE
COMPARE
DATUM
R_0
R_{01}, R_{02}, R_{03}---ETC.
R_0
R_{F1}, R_{F2}, R_{F3}---ETC.
R_F
R_{S1}, R_{S2}, R_{S3}---ETC.
R_S
T_1, T_2, T_3---ETC.
T
$\Delta_1, \Delta_2, \Delta_3$---ETC.
T_{ref}
1
2
5
7
9
11
13
15
17
19
21
23

SPECIFICATION

G n ration f signals dep ndent up n temperatures of gas turbine rotor blades

The present invention relates to apparatus capable of generating a monitor signal for use in operation of a gas turbine engine, said monitor signal being dependent upon the temperatures of a stage of turbine rotor blades in the gas turbine engine.

It is known to control fuel flow to the combustion chambers of a gas turbine engine in partial dependence upon a pyrometer-derived control signal bearing a relationship to the temperature of the high pressure stage turbine rotor blades, but problems have been experienced in designing pyrometer-linked apparatus which can provide a fuel control system with a signal which (insofar as the response time of the control system is concerned) is congruous with changes in the instantaneous average temperature of all the rotor blades in the stage, even during periods when the rotor blade temperatures are changing rapidly, as for example when the engine is being rapidly accelerated or decelerated. Such a "real time" signal is particularly required for fuel control systems which exercise continuously active control of fuel flow in accordance with blade temperature rather than occasional control merely to avoid hazardous overheating of blades.

It is an object of the present invention to facilitate the provision of such a pyrometer-derived signal.

The present invention provides apparatus for generating a monitor signal for use in the operation of a gas turbine engine, said monitor signal being dependent upon the temperatures of a stage of turbine rotor blades in the gas turbine engine, said apparatus including: optical radiation pyrometer means which in operation produces a radiance signal comprising a first component representative of the real-time average radiance of the hottest parts of an integer number of turbine rotor blades, and a second component due to transient interference from non-blade sources of radiation, said integer number being a fraction of the total number of blades on the rotor; and signal processing means adapted to derive said monitor signal from said radiance signal.

The real-time radiance signal is described as comprising two components because a further problem arises from the fact that the field of view of the optical radiation pyrometer is liable to be crossed at intervals by sources of radiation relating to the combustion process. Th se non-blade sources of radiation cause the basic blade-originating component of th radiance signal to b transiently over-lain by an "interference" comp n nt, making it unsuitable for direct use as a control signal.

C nsequently, we prefer that the signal processing means includ s signal filtering means adapt d to filter out the second component of the radiance signal.

Depending upon the design characteristics of the engine and the turbine blades and also upon the magnitude of the above-mentioned integer number, the filtered radiance signal can be subject to fluctuations in strength due to differences in the individual average radiances of neighbouring blades on the rotor. This again might render the signal unsuitable as a control signal.

Accordingly the above-mentioned apparatus preferably further includes signal smoothing means adapted to reduce the amplitude of fluctuations in the strength of the first component of the radiance signal.

Preferably, the optical radiation pyrometer means comprises an optical radiation pyrometer according to the invention disclosed in our copending British patent application number 8330307, and the signal filtering means comprises signal processing means operating according to Claim 2 of our prior British patent number 1590835.

Further aspects of the invention will become apparent from the following description and claims.

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawing, which is block diagram showing the functional layout of digital electronic signal processing apparatus linked to an optical radiation pyrometer.

In the drawing, an optical radiation pyrometer 1 monitors the radiance of turbine rotor blades in a gas turbine engine (not shown) and delivers an amplified radiance signal R_o in analogue form on line 2 to an analogue-to-digital converter (ADC) 3 which is triggered at high frequency on line 5 to sample R_o and give a digital version comprising data word outputs R_{o1}, R_{o2}, R_{o3} . . . etc at that frequency on line 7.

Signal R_o consists of two components, namely a basic blade radiance component and an intermittent interference component superimposed thereon. Filter function 9 moves the latter component and outputs a filtered radiance signal R_F on line 11 comprising data words R_{F1}, R_{F2}, R_{F3}, etc which may fluctuate in value as explained later. They are consequently passed to a smoothing function 13 whose output R_s on line 15 is a stream of data words R_{s1}, R_{s2}, R_{s3}, . . . etc representing blade radiance values acceptable for derivation of a control signal therefrom by subsequent means in the system.

If necessary, the smoothed radiance signal R_s is converted to a temperature signal T by lin arising function 17 whose output of data words T_1, T_2, T_3 . . . tc on line 19 represents turbine blade t mp rature values. These are pass d to a comparat r function 21 which compares data words T_1, T_2, T_3 . . . etc with blade temp rature reference value(s) T_{ref} from a datum unit 23 and produces a control signal Δ by evaluating th differ nce b tween T and T_{ref}, th signal Δ comprising data words Δ_1, Δ_2, Δ_3 . . . etc which are deviations from a null signal.

fuel economy and blade life usage at the various engin conditions, and the comparator function performs the operation

$$T_{ref}-T=\Delta$$

where Δ may be zero, positive or negative and is used by the control system as a trimming signal in conjunction with other signals representing variation of other engine parameters.

Although the comparison function has been described in terms of comparison of temperature signals, it should be noted that in the absence of a requirement for the linearising function, it would be equally possible to compare the radiance signal R_s with a reference radiance signal generated by a suitably modified datum unit 23, and produce a control signal Δ which depended directly on blade radiance data rather than blade temperature data derived from blade radiance data.

In the above paragraphs, reference was made to the convenience of carrying out the linearising and scheduling functions in a microprocessor. It will be apparent that the filtering, smoothing and comparison functions could also be incorporated in a suitably programmed microprocessor.

Note that although the above description has been concerned with use of the invention to produce a control signal for a fuel control system, the signal R_0 (in digital or analogue form) could be passed to known types of "peak-picking" circuitry synchronised with the frequency of passage of the blades through the field of view of the pyrometer in order to detect and positionally identify blades which are running at hotter temperatures than the others and which will thus have reduced operational life. Further, the signal on line 11 or line 15 could be utilised as an input to a device recording elapsed fatigue life for the typical blade on the rotor.

Claims

1. Apparatus for generating a monitor signal for use in the operation of a gas turbine engine, said monitor signal being dependent upon the temperatures of a stage of turbine rotor blades in the gas turbine engine, said apparatus including: optical radiation pyrometer means which in operation produces a radiance signal comprising a first component representative of the real-time average radiance of the hottest parts of an integer number of turbine rotor blades, and a second component due to transient interference from non-blade sources of radiation, said integer numb r being a fraction of the total number of blad s on th rotor; and signal proc ssing means adapted to derive said monitor signal from said radiance signal.

2. Apparatus according to claim 1 in which the signal proc ssing means includes signal filtering means adapted to filter out the second c mponent of th radiance signal.

3. Apparatus acc rding to claim 2 in which the signal pr cessing m ans further includes signal smoothing means adapted to reduce th amplitude of fluctuations in th strength f the first component of the radiance signal.

4. Apparatus according to claim 2 in which the signal processing means further include signal generating means for generating a reference signal representing at least one predetermined blade radiance value and signal comparator means for comparing the reference signal with the filtered radiance signal and producing a further radiance signal dependence upon the difference between the values of the reference signal and the filtered radiance signal said further radiance signal being suitable as a control signal for a fuel control system of the gas turbine engine.

5. Apparatus according to claim 3 in which the signal processing means further includes signal generating means for generating a reference signal representing at least one predeteremined blade radiance value and signal comparator means for comparing the reference signal with the smoothed radiance signal and producing a further radiance signal in dependence upon the difference between the values of the reference signal and the smoothed radiance signal, said further radiance signal being suitable as a control signal for a fuel control system of the gas turbine engine.

6. Apparatus according to claim 2 in which the signal processing means further includes means for converting the filtered radiance signal to a first temperature signal, signal generating means for generating a reference signal representing at least one predetermined blade temperature value and signal comparator means for comparing the reference signal with the first temperature signal and producing a second temperature signal in dependence upon the difference between the values of the reference signal and the first temperature signal, said second temperature signal being suitable as a control signal for a fuel control system of the gas turbine engine.

7. Apparatus according to claim 3 in which the signal processing means further includes means for converting the smoothed radiance signal to a first temperature signal, signal generation means for generating a reference signal representing at least one predetermined blade temperature value, and signal comparator means for comparing the reference signal with the first temperature signal and producing a second temperature signal in dependence upon the difference between the values of the reference signal and the first temperature signal, said second temperature signal being suitable as a control signal for a fuel control system of th gas turbin engine.

8. Apparatus according to any ne f claims 2 to 7 in which th signal filtering means comprises signal processing means adapted to operat according to claim 2 of our prior British patent number 1590835.

9. Apparatus according to any one f claims 1 to 8 in which the optical radiation pyr met r means compris s an optical radiation pyrometer acc rding t the invention claimed in our

copending British patent application number 8330307.

10. Apparatus for providing a gas turbine engine fuel control system with a signal which is dependent upon the real-time average temperature of the hottest parts of an integer number of turbine rotor blades in the engine, substantially as described in this specification with reference to and as illustrated by the accompanying drawing.

11. A fuel control system for a gas turbine engine, said system including apparatus according to any one of claims 1 to 10.

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